Louisiana EPSCoR
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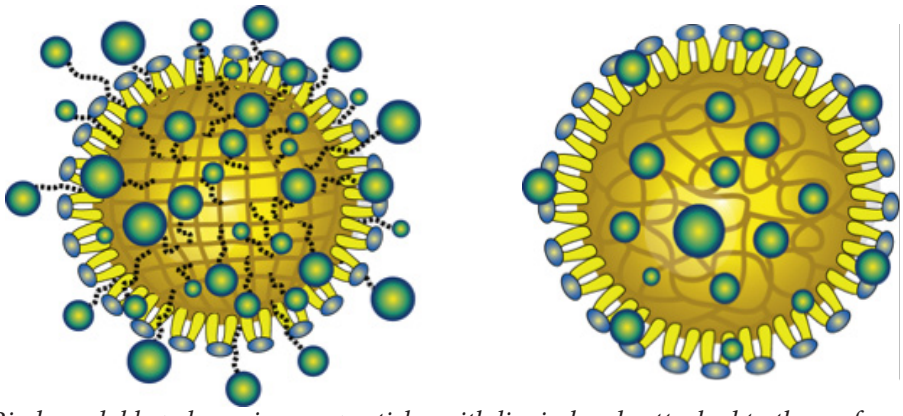
New Class of Biobased Materials Emerging from Ag-Science Collaboration

Tailgating at football games is an important pastime in Louisiana. Barbecues, smokers, and boiling pots are brought to campuses where sausage, gumbo, seafood and meats are carefully prepared for hungry fans. Can you smell it already? That delicious aroma and taste found in smoked foods is due to science! When the pit master throws hardwood into the smoker, the heat breaks down the lignin in the hardwood plant tissues, creating aromatic smoke that flavors the food.

Beyond barbecue, lignin is a low-value byproduct used by industry mostly as a source of biomass for burning. The other two major components of plant tissues, cellulose and hemicellulose, are converted into paper products, sugars, and fuels like ethanol.

However, the lowly lignin is about to get a new use: Researchers are investigating the chemistry of lignin in order to create an entirely new class of industrial and biomedical materials from this renewable resource. This new class of materials is poised to bring a huge boost to the biological industries, as well as generating new highly-skilled jobs and training of young Louisiana researchers and students.

In the long term, the development of materials with a renewable resource such as lignin can positively impact the environment by gradually moving away from a fossil-fuel based industry to an industry based on green technologies.



Biodegradable polymeric nanoparticles with lignin beads attached to the surface (left) or entrapped (right). The nanoparticles can be customized to deliver molecules, like medications, into targeted cells or tissues. Source: LSU AgCenter.

The lignin research team, led by Dr. Dorin Boldor, Charles P. Siess Jr. LSU Professor of Engineering at the LSU AgCenter Department of Biological and Agricultural Engineering, is a collaboration of researchers from three institutions: LSU AgCenter, LSU, and the University of Kentucky.

Dr. Dorin Boldor, LSU AgCenter

The National Science Foundation (NSF) has recently selected the team for a $4 million Research Infrastructure Improvement Track-2 Focused EPSCoR Collaboration (RII Track-2 FEC) award. These NSF awards focus on "innovative science and engineering pathways to produce new knowledge and novel technologies to solve the challenges of scarcity and variability at the intersection of food, energy and water systems."

"We are looking to add value to lignin, an otherwise low-value product, and, at the same time, help young researchers to pursue research avenues that will place them at the forefront of their field in the biobased economy," said Dr. Boldor.

The team is researching the deconstruction and reconstruction process of lignin at the molecular level so new materials can be created out of the lignin building blocks. The deconstruction process is very challenging because a high level of precision is needed to break down the lignin into the exact size and com-

"The possibilities are vast for these new materials. The impact of this EPSCoR project can be felt to areas ranging from improved delivery mechanism of bioactive and potential drug compounds through food, development of improved methods for water treatment and purification, and improved separation processes for chemical industries that reduce energy consumption."

- Dr. Dorin Boldor, LSU AgCenter

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pounds needed for the rebuilding process, else it would break up into individual atoms.

Once the lignin is deconstructed into lignin monomers, novel chemical processes are used to reconstruct the lignin building blocks into a new class of materials, dubbed "lignin beads." The researchers are investigating several new medical and industrial applications for the lignin beads.

One new medical application with enormous potential is a new kind of antimicrobial. Research has shown that some bacterial cell processes are disrupted by specific compounds in lignin beads. The team intends to investigate all of the effects that lignin beads have on biological cells and tissue. The future could hold the possibility of designing an antimicrobial product that targets dangerous bacteria or cancer cells.

Another medical application being researched is the assembly of nanoparticles. "We can make nanoparticles directly out of these structures or attach lignin beads to other nanoparticles," said Boldor. Dr. Cristina Sabliov, with the LSU AgCenter Department of Biological and Agricultural Engineering, is developing biodegradable polymeric nanoparticles (see front page illustration) that can be customized to hold medication molecules targeted to certain areas of the body. The product is swallowed by the patient and remains intact until it reaches the targeted tissues, like the stomach or intestines, and then the medication is released from the nanoparticle exactly where it is needed.

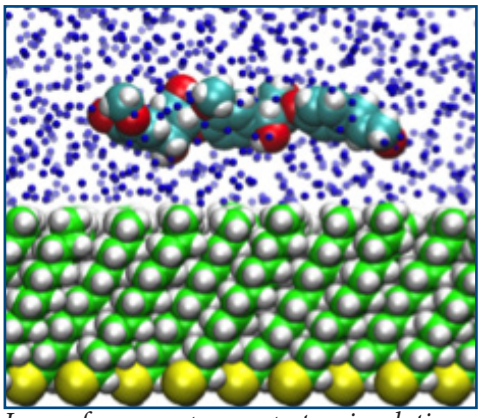

Image from a supercomputer simulation of the molecular behavior changes that occur when a lignin bead (light blue/red) in a solvent solution (dark blue specks) nears a surface (green). Source: LSU AgCenter and Dr. Dorel Moldovan, LSU.

Still another application is in industrial products such as thin films and membranes, which are actively being researched for use in water purification and other separation processes. Thin films separate compounds by attracting targeted molecules to the surface and keeping them there until they are ready to be released. Membranes are used to separate chemical or biological compounds by passing them through pores.

Several industry partners are already on board, including the Louisiana Forestry Association, the Louisiana Chemical Manufacturing Initiative and the Kentucky Association of Manufacturers.

Due to the complexity and molecular scale of these tiny building blocks, the team that has been assembled for this research is quite interdisciplinary, including scientists in computer science, chemistry, biology, and five engineering thrusts: agricultural, chemical, industrial, mechanical, and biological.

The team is composed of: Dr. Dorin Boldor (Principal Investigator (PI), LSU AgCenter), Dr. Dorel Moldovan (co-PI, LSU College of Engineering), Dr. Cristina Sabliov (co-PI, LSU AgCenter), Dr. Sue Nokes (lead co-PI University of Kentucky), Dr. Bert Lynn (co-PI, University of Kentucky). Senior collaborators include: Dr. Carlos Astete and Dr. Pranjali Muley (LSU AgCenter), Dr. Lavrent Khachatryan, Dr. Elizabeth Martin, and Dr. Jangwook Jung (LSU), Dr. Jian Shi, Dr. Stephen Rankin, and Dr. Barbara Knutson (Univ. of Kentucky).

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